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Research Article

Effectiveness of Pilates Based Core Strengthening in Improving Flexibility and Quality of Life in Young Adults with Patellofemoral Pain Syndrome– A Randomized Control Trial

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A B S T R A C T

Background: The Patellofemoral Pain Syndrome (PFPS) is a common cause for "anterior knee pain" and affects 28.9% adolescents with a greater prevalence seen among Indian adolescent females. Symptoms increase with activities such as running, stairs climbing, squatting etc. Weakness or dysfunction in the hip and core muscles can lead to unusual stresses on the patellofemoral joint. Core stability strengthening, in addition to traditional physical therapy, has been found to be significant in improving PFPS symptoms. Pilates as an exercise program has been found to work on core muscles.

Objectives: To find if Pilates based core strengthening is effective in improving pain, flexibility and quality of life in young adults with patellofemoral pain syndrome.

Material and Methods: RCT was selected as study design. A total of 84 participants who fulfilled the eligibility criteria were recruited and randomized into the Control and Experimental group. A protocol of 40 minutes per session, three sessions per week for 8 weeks was given in both the groups. Control group received the conventional physiotherapy whereas the Experimental group received Pilates based sessions. Numerical Pain Rating Scale (NPRS) scores, Flexibility test, and KOOS-PF scores were taken as outcome measures. Data was analyzed in SPPS. Z test and non-parametric test were applied to analyze Flexibility tests and KOOS-PF scores respectively.

Results: NPRS average value at baseline for Intervention group was 8.3 ± 1.98 and shifted to 5.4± 1.032 after treatment. For the control group NPRS value changed from 7.8±1.56 to 5.9±1.02 (p value ≤ 0.05). At the baseline for the flexibility test was 19.6 and 3.15 respectively in the experiment group, which was also significant (p≤0.05). The findings of KOOS-PF scores came out to be insignificant.

Conclusion: A Pilates-based program is more useful than the conventional Physiotherapy in treating patellofemoral pain syndrome (PFPS), among adolescents.

Keywords: Pain syndrome, Exercise, Knee injury, Numerical Pain Rating Scale, Pilates-based program, Ober's test

Introduction

Patellofemoral pain syndrome (PFPS) affects 28.9% adolescents and it seems that there is greater prevalence of PFPS among adolescent females in India. PFPS is a disorder of the patellofemoral joint whose main characteristics are peripatellar, anterior, and even retro-patellar pain that increases with knee flexion and extension and actions such as running, going up and down stairs, walking, squatting and postures such as prolonged sitting or sitting on the knees. The PFPS is a common cause for "anterior knee pain" and mainly affects young adults without any structural changes such as increased Q-angle or significant pathological changes in articular cartilage. Factors that may contribute to its development include sudden change in physical activity, weak thigh muscles, tight hamstrings, tight Achilles tendons, poor foot support, and injury.[1]

The imbalance between the Vastus Medialis Oblique and Vastus Lateralis can lead to increased lateral stress in Patellofemoral joint.[2] More recently Patellofemoral pain has been proposed to be related to reduced strength of hip musculature, such as abductors, external rotators, and extensors. The transversus abdominus and multifidus muscles are believed to be associated with inward rotation and femoral adduction.[3,4] Excessive inward rotation of the femur causes relative outward rotation in the tibia. This position enhances the Q angle; accordingly, it increases the contact surface of the outer part of the patella with the external epicondyle of the femur. Performing repetitive and continuous movements in this position destroys the cartilage under the patella.[2] Decreased pre-contraction of the trunk and hip stabilizers may lead to excessive trunk displacement in the frontal plane. This process could also increase the load on knee and secondarily may lead to disorders and injury in the knee due to lack of control over the centre of mass.[3]

It has been shown that weakness or dysfunction in the hip and core muscles can lead to abnormal movement patterns, such as increased femoral adduction and internal rotation, and dynamic knee valgus, which can cause unusual stresses on the patellofemoral joint and eventually lead to an inflammatory response and pain.[5] Furthermore, weak hip and core muscles can lead to imbalances in the muscles surrounding the knee, such as the quadriceps and hamstrings, which can also contribute to knee pain and dysfunction.[6,7] A study found that core stability exercise program, in addition to traditional patellofemoral pain syndrome exercises, resulted in significant improvements in pain and dynamic balance in patients with PFPS compared to traditional exercises alone.[8]

A study found that core stability exercise program, in addition to traditional patellofemoral pain syndrome exercises, resulted in significant improvements in pain and dynamic balance in patients with PFPS compared to traditional exercises alone.[8,9] Another study demonstrated that adding core exercises led to lesser pain and better function compared with traditional exercises alone.[10]

Pilates is an exercise program that focuses on strengthening the core muscles, which includes the muscles of the lower back, hips, pelvic floor, and abdominal area.[11] While there are other techniques of core strengthening present, the main difference between Pilates and other core strengthening exercises lies in their approach, focus, and methodology. While Pilates is a comprehensive exercise program that emphasizes full-body strength, balance, and flexibility it is designed to strengthen the deep core muscles, such as the transversus abdominis and obliques, which support the spine and improve posture.[12]

Although various interventions, such as physical therapy, quadriceps strengthening exercises, and bracing, have been employed in the management of PFPS, there is a growing interest in Pilates-based core strengthening exercises as a potential therapeutic approach. However, limited research has systematically examined the effectiveness of Pilates-based core strengthening in adolescent population. Therefore, we aimed to find if Pilates based core strengthening is effective in improving flexibility and quality of life in young adults with Patellofemoral pain syndrome. The main objective of our study was to compare the effects of Pilates with Conventional physiotherapy on flexibility and quality of life in adolescents suffering from PFPS. We hypothesized that Pilates-based core strengthening can significantly improve the quality of life and flexibility in young adults diagnosed with patellofemoral pain syndrome (PFPS) compared to a standard physical therapy program.

Methods

The study was a Randomized control trial design in which patients were randomized into Control and Experimental group after providing the informed consent. The experimental group participated in a Pilates based core strengthening program, while the control group received a standard conventional physiotherapy program. A total of 84 participants who fulfilled the eligibility criteria were recruited from various OPDS and Clinicalset-ups. Subjects of age 12 to 19 yrs having Anterior/ Retro-patellar knee pain for more than 3 months and who had more than 2 clinical function tests (Squatting, Prolonged sitting, Stair ascending or descending and Kneeling) positive were selected. Participants having any condition related to Lower limb ligaments, meniscus injury, Prior knee surgeries or knee injuries any medical conditions severely limiting physical activity, such as Patellar dislocation or instability were excluded. Subjects having Concurrent engagement in any other rehabilitation programs were also excluded.

VAS was taken to assess pain score. Knee Injury and Osteoarthritis Outcome Score Patellofemoral' (KOOS-PF) questionnaire was selected to evaluate improvement in Quality of life. Along with this Ober's test and 'Sit and Reach test' was used to evaluate improvement in flexibility of the subjects. All the subjects were assessed over a period of 8 weeks, with measurements taken at baseline and at the 8th weeks to evaluate the potential improvements in the outcome measures.

After receiving Ethical clearance from the Institutional Review Board, written consent was obtained from all the participants who fulfilled the, eligibility criteria. After which the participants were randomized to the study groups. Patients then underwent a baseline assessment including a standardized clinical examination protocol for patellofemoral pain. The KOOS-PF questionnaire was filled by the subjects. 'Sit and Reach test' and Ober's test were also performed to complete the baseline assessment of all the subjects. Participants in the control group received a 40-minute conventional physiotherapy treatment and stretching program for 8 weeks. Sessions were conducted thrice per week. Each session starts with 30 minutes of conventional treatment which includes moist heat, knee isometrics exercises, and a 10-minute stretching program. Routine exercise program focused on quadriceps strengthening using selected closed and open chain exercises (CKC and OKC) plus hamstring, quadriceps and iliotibial band stretch was prescribed for control group Participants were also instructed to practice isometrics exercises for 10 min daily at home. All participants were encouraged to maintain their usual physical activities and to perform no additional strength training other than stretching and isometric exercises.

For intervention group Pilates exercise protocol of 40 minutes /session, three sessions per week for 8 weeks was given and set of exercises changes bi- weekly. Subjects performed the Pilates on Mat using Pilates Band. Different exercise chosen were Gluteal bridge, Plank, Clam level 1,2 and 3, Hundredth exercise, Standing footwork, Single leg stretch, Hip twist, side kick with rotation and Squats. The progression of exercise was done based on their difficulty level and repetitions were increased gradually. The outcome measures were re-assessed in a single session after completion of 8-week exercise period.

Data Analysis

The statistical analysis was done using SPSS version 16. There were no drop outs in the study. The mean and standard deviation were calculated for experimental and control groups. The between and within group analyses of the Numerical Pain Rating Scale (NPRS) and Flexibility test readings were done using the Z test. Analysis of KOOS PF scores was done via Wilcoxn Rank test and Mann Whitney-U test. Table 1 depicts the Mean and SD Intragroup (between pre and post) for NPRS and Flexibility tests respectively. Table 2 depicts the analysis of KOOS PF scores. The threshold for statistical significance was set at $P < .05$.

Results

Following the enrolment of eligible patients, the treatment session was administered to the participants. There was a researcher present during each session. 84 eligible participants were randomized into the groups, with 42 subjects in each group. The control group had 30 females and 12 males. The Intervention group had 34 females and 8 males. The mean age of the total participants was 16.7 years whereas the mean age of control group was 15.8 years and that of the intervention group was 16.2 years. There NPRS at baseline for Intervention group mean scores of 8.3 ± 1.98 shifted 5.4± 1.032 to after treatment. For the control group NPRS values changed from 7.8±1.56 to 5.9±1.02. The p value came out to be significant for NPRS ($p \leq 0.05$). The mean and standard deviation of experimental group at the baseline for the flexibility test was 19.6 and 3.15 respectively. The p value obtained for the Z test for between group analyses of flexibility tests were found to be significant ($p \leq 0.05$) (Table 1).

The KOOS-PF scores were also improved in both the groups significantly and decrease in scores was significant in experiment group (Table 2).

Table 1.Average scores of Numerical Pain Rating Scale (NPRS) and Flexibility (Sit & Reach test and Obers test) for both control and Experimental groups

Groups	NPRS Mean &SD		Sit & Reach test Mean &SD		Ober's test Mean &SD	
Control Group	Pre - 7.8±1.56		Pre - 18.43± 3.45		Pre - 1.73± 0.45	
	Post - 5.9±1.02		Post - 19.8± 2.11		Post - 1.4± 0.50	
Experimental group	Pre - 8.3 ± 1.98		Pre - 19.6± 3.15		Pre - 1.66± 0.48	
	Post - 5.4± 1.032		Post - 22.03± 3.11		Post - 1.13± 0.35	
Control Group Vs Experimental group	Z value	P value	Z value	P value	Z value	P value
	1.28	p≤0.05	1.58	p≤0.05	1.09	p≤0.05

Pre Vs Post in experimental and control group is found significant ($p<0.05$)

Table 2.KOOS-PF Score Between the group and within the group

Groups	KOOS-PF (Quality of Life)	T Value	P Value
Control Group	Pre – 36.52± 10.69	12.83	0.001
	Post - 9.21± 6.09		
Experimental group	Pre – 44.33 ± 6.32	21.84	0.001
	Post – 9.99± 2.67		
Post intervention Control Vs Experimental groups	-	2.24	0.03

Discussion

The purpose of this study was to ascertain whether Pilates-based core strengthening could improve flexibility and quality of life in young adults with patellofemoral pain syndrome. The results of this novel treatment approach contribute to the understanding that patellofemoral pain syndrome is a biomechanical change of the body, not just the knee joint. The gender wise distribution of the subjects seen in both the groups aligns with the literature stating that PFPS is seen more in females. When comparing the two groups, the results showed that the p-value for the flexibility tests and Numerical Pain Rating Scale (NPRS) scores was significant. Both groups experienced significant improvements in pain on NPRS, but the improvements were superior in the experimental group. When it came to flexibility tests, the experimental group outperformed the control group, but within-group analyses revealed that both groups had improved. The mean value of Ober's test and Sit and Reach test improved for both the groups. However greater improvement was seen within the Experimental group. In a study done by González et al. in 2023, mat-based Pilates exercise program improved dynamic knee valgus alignment in the runners, not only this the core strength also improved in the subjects.[13] In a review study done by Caglar et al. 2024 studied impacts of Pilates on the core strength core muscle thickness, balance and quality of life, concluded that Pilates is a regime that re-establishes mind-body connection needed for core stability, flexibility, and strength as well as focus on breathing, posture, and muscle control.[14] This simply explains the clinically significant results obtained in our study.

In this study, the KOOS- PF scores did not demonstrate statistically significant differences between the groups. Although changes in the scores have occurred for all the participants but for KOOS-PF to be clinically significant and outside the measurement error range, there must be a change of at least 16 on the score. This is an issue in circumstances like exercise or physical therapy where minor but clinically significant changes occur but are non-measurable quantitatively.[15]

Results of this study are consistent with studies reporting the effectiveness of hip and core exercises on primary outcomes of pain and function. A study investigated effects of conservative physical treatment with core neuromuscular training for 4 weeks, on patients of PFP, found that pain level was substantially reduced in both of the groups ($P < 0.05$) with Intervention group showing better results.[16]

In a similar study done by Behnaz Tazesh et al. in 2020 on 64 patients of PFPS, improvements in outcomes were noticeably higher in the intervention group which received core strengthening along with the conventional treatment.[3] Due to more significant results in the experimental group, we can use Pilates based core strengthening exercises for PFPS treatment as these engage the muscles in a more functional and dynamic manner, which can lead to greater improvements in pain and function compared to traditional exercises. This functional approach can help to improve overall muscle coordination and reduce the risk of further injury. Furthermore, Pilates-based core strengthening exercises have been shown to be more effective in reducing pain and improving function compared to conservative physical therapy alone.[17,18]

limitations

In the study such as follow-up evaluations to ascertain whether the interventions remain effective in longer run, could not be done as it was not feasible to extend the study period beyond 8 weeks because of problems in participant compliance.

Conclusion

With this study we concluded that both types of interventions were effective in mitigating the symptoms. A Pilates-based program is more useful in treating patellofemoral pain syndrome (PFPS), Hence adding Pilates based exercises along with the conventional physiotherapy program will produce best results.

Conflict of Interest: None

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Declaration of Generative AI and AI-Assisted Technologies in the Writing Process: None

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